Biology

Research Topic: Optimum amount of ammonia (NH_3) solution concentration has the greatest effect on the growth of *Lens culinaris* (Lentil) counted by the number of seeds.

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Abstract

In my research, my aim has been to find out optimum amount of ammonia (NH_3 solution) to raise the yield of *Lens culinaris* (Lentil), so that maximum amount of *Lens culinaris* (Lentil) can be obtained to satisfy protein demand of developing and underdeveloped countries with limited agricultural land available and minimum input costs. In my research, I found out that Nitrogen and Phosphate were critical elements for raising the quality of food crops. However, I found out that there were a great deal of studies on phosphatic fertilizer while there was few, if no, study on the effects of Nitrogen in *Lens culinaris* (Lentil) farming, partly because Nitrogen was deemed to have a slightly less contribution on the growth than Phosphate. So, my research would close a gap in the literature to an extent. In the study I picked ammonia (NH_3 solution) which is a Nitrogen rich fertilizer.

To prove my hypothesis, I set up an experiment which took me 7 months to complete. The number of *Lens culinaris* (seed number) was dependent variable, other independent variables, such as irrigation, sun radiation etc. were kept constant while amount of ammonia (NH_3 solution), an independent variable, was changed during experiment. After germination, the seeds were separated according to the height of the each individual crop into 5 distinct groups. 25 pots with 5 different colors representing groups were used. The first group was labeled as "Control Group" which would not receive any ammonia (NH_3 solution), representing a reference point. Experiment Group-1 was the group that would be treated with 5 mg. of ammonia (NH_3 solution), Group-2, Group-3 and Group-4 would be treated with 10 mg., 15 mg. and 20 mg. of ammonia (NH_3 solution) respectively. Counting the seed number of the crop in each pot simultaneously was conducted in every 10-day interval for 90 day period.

Results I obtained supported my research question and validated my hypothesis that optimum amount of ammonia (NH_3 solution) concentration has the greatest effect on the growth of *Lens culinaris* (Lentil).

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INTRODUCTION

In the evenings when I sat in front of TV set, incidents related to human suffering all over the world strike me which lead me to contemplate root causes of them. Immigration in masses, human trafficking, terrorism, **changing nature of regional wars between states and non-state actors**, climate change and water scarcity all of which end up with the suffering of human beings. Since my childhood those scenes on TV and my partial personal experience but mostly experiences from my father, who worked for United Nations in many parts of the world have indicated that the real problem behind those tragedies stem from uneven distribution of the wealth of the production due a number of reasons ranging from economy, politics to human greed. In the face of global problems local, indigenous solutions gain importance, especially those in the field of food security without which livelihood would become impossible. **Hailing from that contemplation**, I had decided to investigate the effects of fertilizers extensively used in agriculture, which I had been observing gaining momentum in **its increased usage to reap more crop from**. In my country, in particular, farmers tend to use excessive use of fertilizers resulting from low education, a handicap which should be addressed.

On the other hand, as the population of the world continues to grow, hunger, famine and starvation is becoming harder and harder to feed human beings. As scientists search for a solution to this problem, agriculture becomes an obvious and indispensable alternative.[1]

How to get food into the mouths of nearly one billion people who are currently undernourished is the most challenging problem in the world[2]. A type of food which provides not only high quality protein but also accessible and affordable should I be finding. Only in the US, 157 million tons of vegetable protein is fed to livestock to produce just 28 million tons of animal protein in the form of meat.[3]

So the vegetable protein has emerged to be a good solution to the food security and securing protein for the people. Such as, an acre of legumes such as beans, peas and lentils (From *Fabaceae* Family, *Lens culinaris*) produces ten times more protein than an acre used for meat production.[4] Accessing protein being an expensive option, there are still ways to feed that portion with a less expensive and highly efficient methods. This is legumes, which are the inexpensive source of protein, calories, minerals and some vitamins. Legumes are

[1] Accessed on 01 April 2015, http://www.agriculture.gov.sk.ca/Kelsey_Richardson
[2] Accessed on 25 March 2015, Feed the World, http://www.viva.org.uk/feed-world
[3] Jeremy Rifkin, introduction to *Feed the World,* Viva! (Vegetarians International Voice for Animals) Guide No. 12.
[4] Accessed on 19 July 2015, Feed the World, http://www.viva.org.uk/feed-world

fundamental components in the diet of 700 million people in the world, especially in developing countries.[5]

In my research, I found out that Nitrogen was a critical element for increasing the quality of food crops. *Lens culinaris* (Lentil) show some variation for plant height, number of branch, number of pod per plant, number of seed per plant, harvest index and biological yield[6] as per the amount of input, namely Nitrogen (N).

So throughout my research, which I think would attract some attention from academic and practitioner circles, I have pursued one main objective and an secondary objective, being the latter is the importance of vegetable protein in terms of ease with which its accessibility and affordability, and the former, main objective, is to show appropriate dozes of use of fertilizers in the process increases the production. To this end, in my research, I have endeavored to reveal the results for correlation between the amount of Nitrogen being an input, and number of seeds (which corresponds to productivity) per plant.

In the experiment process, I will try to find the answer of the question depicted below;

How is the growth of *Lens culinaris* (Lentil) in terms of number of seeds effected by a variety of predetermined amount of concentration of Nitrogen (**NH_3**) solutions added to a five group of soils?

One of the significant aspect of this experiment is to show misuse of fertilizers, here Nitrogen (**NH_3** solution), affects the productivity of *Lens culinaris* (Lentil). This misusage of Nitrogen, often in overdoses, in some case underdoses, generally stems from poor education of the producers, the farmers. Finding out optimal use of Nitrogen could set a model for the plant growth of *Lens culinaris* (Lentil) and a precedence for other legumes family.

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[5] Singh, K., G. Ghosal and J. Sing. 1992. Effect of sulpher, zinc and iron on cholorophyll content, yield protein harvest nutrient uptake of French bean (Phaseolus vulgaris L.). J. Plant Nutr., 15:2025-2033

[6] Karadavut, U. and A. Genc, 2010. Relationships between chemical composition and seed yield of some Lentil (*Lens culinaris*) cultivars. Int. J. Agric. Biol., 12: 625–628

Hypothesis

Lens culinaris (Lentil) is a short, semi erect, annual legume and used for human consumption. It is a main source of vegetable protein in human diet.

Nitrogen is a critical element for raising the quality of food crops, by the same token is an important macro element for growth of *Lens culinaris* (Lentil) as well. It was reported that *Lens culinaris* (Lentil) has different potential in growth and vary in response to different fertilizer levels.[7] *Lens culinaris* (Lentil) being a legume crop can fix atmospheric nitrogen via symbiotic rhizobia in root nodules and consequently has potential for maintaining soil fertility.[8] Although legumes in general, *Lens culinaris* (Lentil) in particular can meet their nitrogen requirements by biological nitrogen fixation, but a starter dose of nitrogen is helpful in increasing the crop yield.[9] Despite having ability to fix atmospheric nitrogen, application of appropriate amount of nitrogen fertilizer in *Lens culinaris* (Lentil) **increases seed number**, thus production.

Hypothesis:

Null Hypothesis; H_0: Number of Lens culinaris* (Lentil) seeds does not change by the amount of NH_3 *solution administered to.

H_1: Number of Lens culinaris* (Lentil) seeds change by the amount of NH_3 *solution administered to.

It suggests a few possible outcomes that Nitrogen raises the productivity or inhibits the growth of the plant, and the yield which is seed number.

After finding out if my hypothesis is accepted or not, I will examine the experiment observation data to discern optimum or breakeven point in terms of amount of NH_3 solution which best serves to obtain more seeds.

My forecast is that *Lens culinaris* (Lentil) plant produces more seeds gradually in direct proportion with the NH_3 *solution administered to until a certain amount (optimum point), and the production in terms of seed number decreases in indirect proportion after that optimum amount.*

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[7] Sadiq, M.S., G. Sarwar, M. Saleem and G. Abbas, 2002. NIAB Masoor 2002 - A short duration and high yielding lentil variety. J. Agric. Res., 40: 187–192

[8] Peoples, M.B., A.W. Faizah, b. Rerkasem, and D.F. Herridge 1989. Methods for Evaluating Nitrogen Fixation by Nodulated Legumes in the Field. ACIAR Monograph No. 11, vii + 76 p., Canberra.

[9] Takishima, Y., Shimura, J. Ugawa, Y., and Sugawara, H. 1989. Guide to World Data Center on Microorganisms with a List of Culture Collections in the World. 1st edition. Saitama, Japan: WFCC World Data Center on Microorganisms.

Method Development and Planning

Creating an available method to support or refute the hypothesis is significant. In my experiment the independent variable is amount of **NH_3** solution which affects the *Lens culinaris* (Lentil) production **(seed number)** which is the dependent variable. Other independent variables which are kept constant are;

- Soil quantity and composition
- Soil thickness, above and below the seed
- Soil suppression
- Size (height, lenght) of pots
- Seed variation
- Planting position of seed
- Air temperature and quality (Adequate ventilation of the room)
- Sun and light radiation and exposure
- Humidity
- Observation periods
- Nitrogen source obtained from the fertilizer
- Concentration preparations timing
- Water quality and quantity
- Watering time

Steps in Method Development

1. Picking dependent, independent variables and constants

In this research, only fertilizer **(Nitrogen (NH_3 solution)) usage will be an independent variable** and all others will be held constant, **while dependent variable is the number of seeds** which denotes the production. Throughout the experiment other independent variables, such as **irrigation, sun radiation, sowing techniques, climate, soil and the others will be kept normal and constant.**

2. Water administration rules and water quality considerations

Fertilizer and water are both the main inputs in the experiment. So, both should be treated in due course. For the sake of keeping the amount of water constant during the experiment, 10ml of water must be administered through an injector at the same exact time at every 10 day intervals, at a specific time which provides minimum evaporations, that is in the evening. For *Lens culinaris* (Lentil) is a semi-hydrophofic plant[10], amount of water should be at a very minimal amount. While watering the plant, it should be directly on the location of the seed sown in the pot for a complete absorption. In the experiment, the quality of water should be kept all the same, so the same trade mark bottled water is used, that is "Elmacik". Official analysis values presented by "Elmacik" water shows that there exists no Nitrogen in the water as shown in the Table-1.

Floride	**0.12 mg/L**
Bicarbonate	122 mg/L
Chloride	1,07 mg/L
Sulphate	5,37 mg/L
Calcium	37,5 mg/L
Magnesium	1,7 mg/L
Potasium	0,3 mg/L
Sodium	2,6 mg/L
Iron	Null
Ph	7,96 mg/L

Table-1 Chemical properties of the water used in the experiment.

[10] Agriculture and Agri-Food Canada. 2000. Canada: Special crops situation and outlook for 2000- 2001. Biweekly Bulletin 13(12): Insert.

3. Fertilizer usage

Nitrogen source of this experiment is Ammonia (**NH_3** solution), since the major use of ammonia is as a fertilizer. Nitrogen is found in the nature in gas state. It is used to make fertilizers, nitric acid, nylon, dyes and explosives. To make these products, nitrogen must first be reacted with hydrogen to produce ammonia. This is done by the Haber process[11].

Addition of Nitrogen (**NH_3** solution) before germination is refrained because doing so could hinder germination. Nitrogen (**NH_3** solution) addition should be done right after the observation of germination above the soil.

4. Soil and its treatment

The soil used in the experiment is very important component of the whole process. Since the composition directly affects the growth of the plant, amount of Nitrogen (**NH_3** solution) in the soil should be homogenous for this experiment to reflect the desired observations, otherwise heterogeneous Nitrogen existence in the soil could easily have a detrimental effect which would lead us to wrong conclusions. Lentil does not tolerate flooded or waterlogged soils, and does best on deep, sandy loam soils. A soil pH near 7.0 is best for lentil production[12].

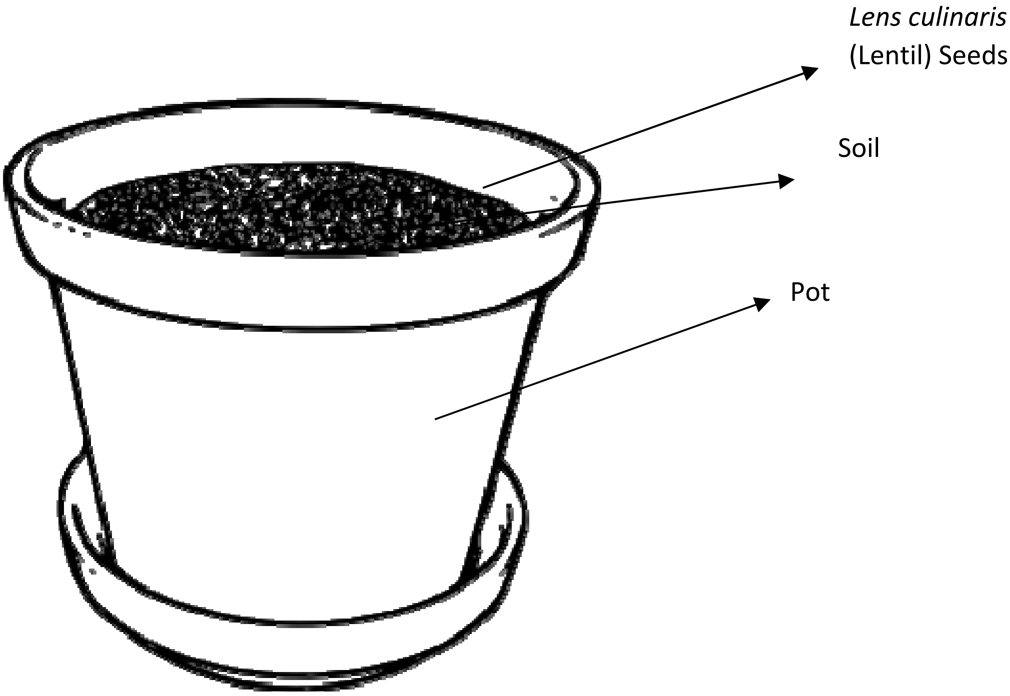
In my experiment ready to use commercially packed soiled is used. According to ingredients given by the producer is given in Table-2;

Total Nitrogen (N)	1,2 mg/L
Amonium Nitrogen (N)	0.075 mg/L
Nitrate Nitrogen (NO3)	0.125 mg/L
Phosphate (P2O5)	5 mg/L
Potasium (K2O)	40 mg/L

Table-2: Chemical ingredients of the soil used

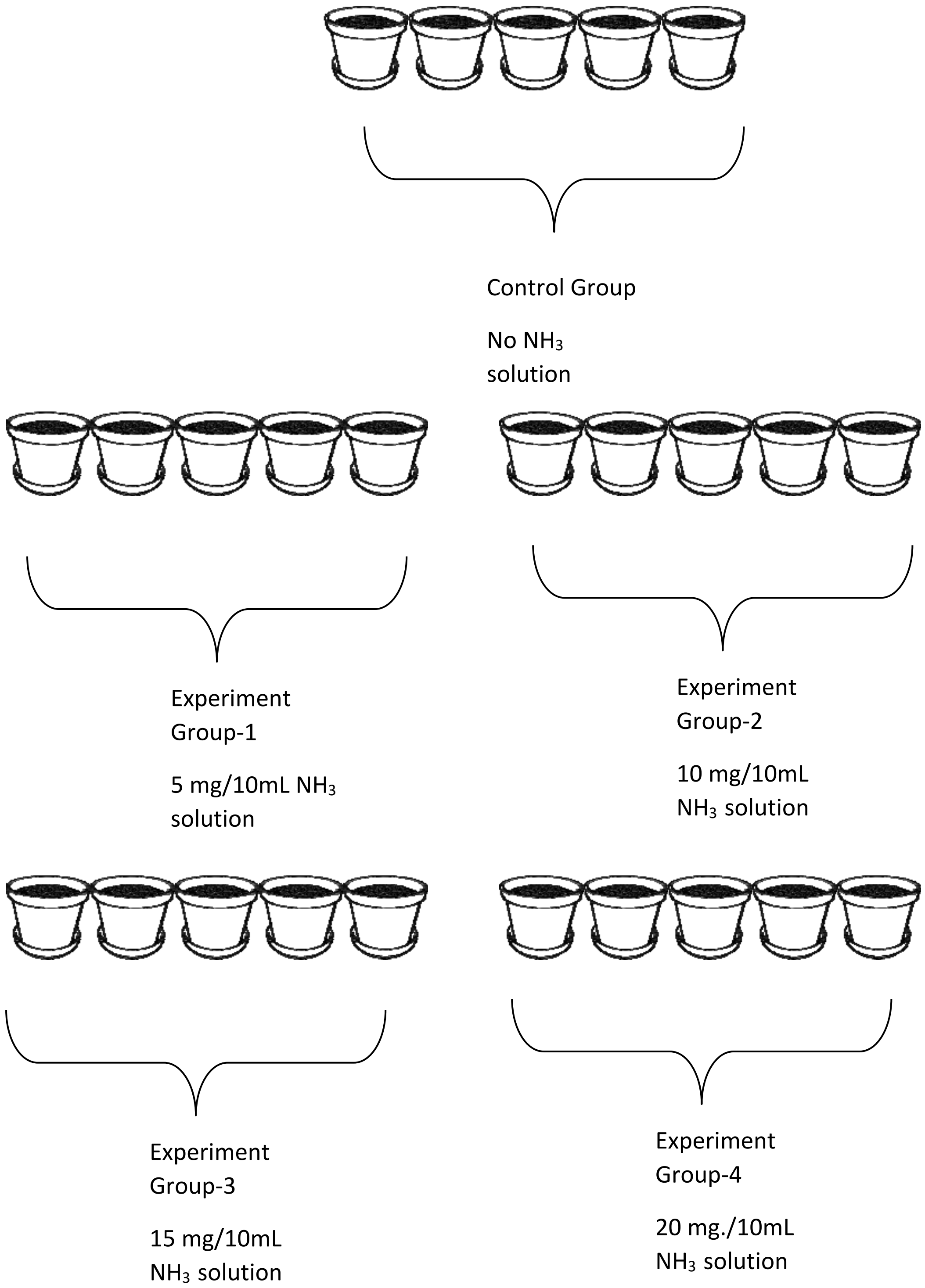
The soil with specifications depicted above should be put in pots of the same size so as to let the seeds grow in an equal space and area.

[11] http://www.rsc.org/periodic-table/element/7/nitrogen
[12] https://www.hort.purdue.edu/newcrop/afcm/lentil.html



Picture-1 Depiction and Dimensions of the pot (1 L)

Figure-1:


Control Group
No NH₃ solution
Experiment Group-1
5 mg/10mL NH₃ solution
Experiment Group-2
10 mg/10mL NH₃ solution
Experiment Group-3
15 mg/10mL NH₃ solution
Experiment Group-4
20 mg./10mL NH₃ solution

5. Germination process

A large tray with cotton layers is for a desirable seedbed for seed **germination** irrigated to get a proper moisture condition 10 days before planting *Lens culinaris* (Lentil). In that large tray almost 300 seeds (Although 250 seeds will be used, 50 more is for contingency) are sown for germination. After germination is obtained, it is of importance that the same sized 250 germinated seeds should be chosen. After germination, the seeds are separated according to the height of the each individual crop into 5 distinct groups which are then re-sowed in 5 separate pots.

6. Sowing process

Right after germination is observed, the lentil will be transferred to pots. 25 pots will be filled with soil of each is 0,2 L. with a weight of 85 grams each. The germinated seeds are to be sown will be put on the first layer of soil surface of 6cm from the bottom in the pot, and then 3 cm. thick of soil will be added on the top. After treating each pot with soil and seeds, the pots should be placed at least 20 cm. apart from one another to prevent shading. Each pot should be placed to benefit from direct sunlight at an equitable manner. In order to get proper, accurate and precise data, pots will have 10 plants in the event that some of plants could die. So that gives me chance to tear the other plants on the other pots. Every group will have 5 trials.

7. Labeling the pots

The first group is labeled as “Control Group” which will not receive any Nitrogen (NH_3 solution), representing a reference point. Experiment Group-1 is the group that will be treated with 5 mg. of Nitrogen (**NH_3** solution), from which I am expecting would yield minimum values, Group-2 , Group-3 and Group-4 will be treated with 10 mg, 15 mg and 20 mg of Nitrogen (**NH_3** solution) respectively. Amount of liquid NH_3 to be used is significant because less may have no effect or more may harm the soil and the plant, and demolish its growing. In Table-3 is the doses of **NH_3** solution.

In this experiment 25 pots with 5 different colors are used, each of the colors representing a group from 1 to 5. The depiction and dimensions of the pots is shown in Picture-1. Grouping of the pots are shown in Figure-1. The steps of choosing control and experiment groups is of significance. Because, this methodology will help us identify the effects of different amounts of **NH_3** solution on the growth of *Lens culinaris* (Lentil), first by bare observation and then by statistical techniques.

The pots are separated into 5 groups, each of which possess 5 pots. Pots are labeled from 1 to 5. Nitrogen (**NH_3** solution) is planned to be applied in the form of ammonium (**NH_3** solution). Doses of **NH_3** solution is applied as shown in Table-3. Having 5 pots in every group renders us repeating the experiment at 5 trials for each Nitrogen (**NH_3** solution) amount.

Doses of NH_3 mg/10mL	Groups
0	Control
5	1
10	2
15	3
20	4

Table-3: Amount of NH_3 solution that will be administered to each respective group.

8. Observation and recording data phase

Counting the **seed number** of the crop in each pot simultaneously is conducted in every 10-day interval for 90 day period which is the time length the plants reach between 25 cm and 35 cm. of height which is the optimal height for the plant to produce seeds. The observation data is recorded in the form as shown in Table 6 through 10 allocating a separate observation form for each of the group. The observation period ended on 15 October 2015.

9. Duration of the experiment

The experiment is planned to take approximately 6 months starting on 15 March 2015, ending on 06 September 2015.

Material and Apparatus

Flower Pot for germination

Flower Pots-1L each- 25

Lens culinaris (Lentil) Seeds (Erzurum-89 Seed Type)-300

Commercial Soil-5L

Liquid Fertilizer-500mL

Elmacik Bottled Water

Medical Injector

Digital Weight

Ruler

Labels

Pen

Method

1. Separate 25 pots and label them as follows

	Control Group	Group-1	Group-2	Group-3	Group-4
Pot-1	G0P1	G1P1	G2P1	G3P1	G4P1
Pot-2	G0P2	G1P2	G2P2	G3P2	G4P2
Pot-3	G0P3	G1P3	G2P3	G3P3	G4P3
Pot-4	G0P4	G1P4	G2P4	G3P4	G4P4
Pot-5	G0P5	G1P5	G2P5	G3P5	G4P5

Table-4: G stands for Group and P is for the Pot. G3P4 is the representative of 4th Pot in the 3rd Experimental Group.

2. Concentration of Nitrogen in the form of **NH_3** solution is given below. Weigh the amount of **NH_3** solution by scaled measure provided with the cap of the liquid fertilizer. Obtain the concentration through mixing fertilizer with a bottle of water of 1 L, of which bottle number-0

is only water, bottle number-2 is mixed with 500 mg of **NH_3** solution, bottle number-3 is with 1000 mg, number-4 is 1500 mg and number-5 is with 2000 mg of **NH_3** solution. Do not change water, which is “elmacik” bottled water.

Mass Concentration of NH_3 Solution (mg/L)	**Bottle**
0	**0**
500	**1**
1000	**2**
1500	**3**
2000	**4**

Table-5: Doses of NH_3 solution by Groups in the bottles (g/L)

3. Keep the solutions tightly closed to avoid evaporation and increase in the concentration. Having 500, 1000, 1500 and 2000 mg of **NH_3** solution in 1 L of water means every 10 mL extracted from the mixture will yield 5 mg, 10 mg, 15 mg and 20 mg of **NH_3** solution in each dose respectively.

4. Pre-prepared commercial soil is used in the experiment. For germination of the seeds 15 days before the experiment starts, take a big enough pot to contain 300 seeds. Plow per cultivations followed by planking were undertaken to make a desirable seedbed for seed germination. When you get proper moisture condition then sow the seed to await the seeds to germinate. See Picture-2 for the tray for germination and the seeds to be sown.

Picture-2: The tray for germination and the seeds to be sown

5. During this time until germination is awaited, use 25 pots with 5 different colors, each of the colors representing a group from 1 to 5. Label them as shown in the Table-3. Fill 25 pots

of the same size so as to let the seeds grow in an equal space and area with soil of each is 0,2 L with a weight of 85 grams.

After the germination is obtained, spare 10 seeds for each of the pots totaling 250 seeds. Keep and spare the rest surviving, already germinated seeds in the germination pot for contingency purposes.

6. For each of the pot repeat the procedure as follows; simply put the germinated seeds of 10 on the first layer of soil surface of 6cm from the bottom in the pot, and then add 3 cm. thick of soil atop as shown in the Picture-3. Do not suppress the soil so as to not close air space in the soil letting the roots of the plant to respiration. After this, place the pots at least 20 cm. apart from one another to prevent shading.

Picture-3: Seed sowing layers (6 cm and 3 cm)

7. Since *Lens culinaris* (Lentil) is semi- hydrophofic plant, water the seeds with due care. From this perspective, water the seeds every ten day intervals at 20.00 hours. Use a medical injector to fill 10mL of solution. Keep in mind each group will receive its respective ratio of **NH_3** solution from the bottles labeled. See Table-3, amount of **NH_3** solution that will be administered to each respective group, and Table-5, doses of **NH_3** solution by Groups in the bottles (mg/10mL) for permanent reference.

8. As per practice and literature, *Lens culinaris* (Lentil) starts to produce seeds 2 months after it is planted. As we planned to sow the germinated seeds on 15 March 2015, first appearance of the seeds on the plant body is expected approximately on 15 May 2015. So, our first observation will begin on that date.

9. On May 2015, make your observation if there is any death plant individual. If there is, pluck it/them from the pot and then even up the number of plants to get a balanced number of plant in each pot.

10. Then counting begins by visual control. Count the number of seeds with due care trying to not harm the branches of the plant. If possible do not touch the branches, make it from a 15 cm distance.

11. After counting each pot in a group, record the numbers with its respective date of observation. Record the data on a form depicted below.

Data Observation Sheets

	Seed Number of *Lens culinaris* (Lentil) *Observed for 120 days by 10-day intervals- **In each Pot, there are 6 plants of Lens culinaris***				
	Control Group-No **NH_3** solution				
Observation Date	G0P1	G0P2	G0P3	G0P4	G0P5
15/05/2015	15	17	14	16	15
25/05/2015	17	19	16	18	18
04/06/2015	21	23	20	22	21
14/06/2015	30	32	29	33	28
24/06/2015	41	42	40	39	40
04/07/2015	50	51	53	52	50
14/07/2015	60	59	57	63	62
24/07/2015	73	71	69	72	73
04/08/2015	82	84	80	84	79
15/08/2015	96	92	90	92	89
26/08/2015	101	103	97	98	95
06/09/2015	104	105	102	101	102

Table-6: Observation results (Seed Number of *Lens culinaris)* for Control Group. G stands for Group and P is for the Pot. For example; G0P3 represents Control Group Pot number 3.

Observation Date	**Seed Number of *Lens culinaris* (Lentil)** *Observed for 120 days by 10-day intervals- **In each Pot, there are 6 plants of Lens culinaris***				
	Experiment Group-1- 5mg/10mL of **NH_3** solution				
	G1P1	G1P2	G1P3	G1P4	G1P5
15/05/2015	17	19	20	16	17
25/05/2015	21	23	24	21	20
04/06/2015	24	27	27	25	27
14/06/2015	34	37	33	35	32
24/06/2015	44	45	44	46	47
04/07/2015	54	55	53	56	55
14/07/2015	64	65	67	63	64
24/07/2015	80	81	84	80	79
04/08/2015	92	94	91	95	89
15/08/2015	104	107	100	109	103
26/08/2015	111	112	114	113	115
06/09/2015	113	115	117	119	117

Table-7: Observation results (Seed Number of *Lens culinaris)* for Group-1. G stands for Group and P is for the Pot.

Observation Date	**Seed Number of *Lens culinaris* (Lentil)** *Observed for 120 days by 10-day intervals- **In each Pot, there are 6 plants of Lens culinaris***				
	Experiment Group-2- 10 mg/10mL of **NH_3** solution				
	G2P1	G2P2	G2P3	G2P4	G2P5
15/05/2015	19	21	20	21	19
25/05/2015	23	25	24	24	23
04/06/2015	25	26	27	26	28
14/06/2015	36	38	37	36	37
24/06/2015	50	51	50	53	54
04/07/2015	62	64	59	64	58
14/07/2015	70	73	72	77	73
24/07/2015	83	86	85	89	84
04/08/2015	97	101	103	100	98
15/08/2015	107	111	115	112	108
26/08/2015	114	114	116	116	119
06/09/2015	119	117	119	121	123

Table-8: Observation results (Seed Number of *Lens culinaris)* for Group-2. G stands for Group and P is for the Pot.

Observation Date	**Seed Number of *Lens culinaris* (Lentil)** *Observed for 120 days by 10-day intervals-* ***In each Pot, there are 6 plants of Lens culinaris***				
	Experiment Group-3- 15 mg/10mL of NH_3 solution				
	G3P1	G3P2	G3P3	G3P4	G3P5
15/05/2015	21	23	22	24	21
25/05/2015	26	27	25	27	25
04/06/2015	30	31	28	32	29
14/06/2015	40	42	38	46	40
24/06/2015	54	52	50	55	54
04/07/2015	67	70	72	68	69
14/07/2015	80	83	85	81	87
24/07/2015	92	95	97	91	90
04/08/2015	110	114	117	109	108
15/08/2015	123	125	130	122	120
26/08/2015	128	129	135	129	126
06/09/2015	134	132	139	138	132

Table-9: Observation results (Seed Number of *Lens culinaris)* for Group-3. G stands for Group and P is for the Pot.

Observation Date	**Seed Number of *Lens culinaris* (Lentil)** *Observed for 120 days by 10-day intervals-* ***In each Pot, there are 6 plants of Lens culinaris***				
	Experiment Group-4- 20 mg/10mL of **NH_3** solution				
	G4P1	G4P2	G4P3	G4P4	G4P5
15/05/2015	15	18	14	16	17
25/05/2015	17	21	17	18	19
04/06/2015	19	22	19	20	21
14/06/2015	25	27	28	26	25
24/06/2015	30	33	34	32	35
04/07/2015	34	38	40	41	42
14/07/2015	40	46	48	45	48
24/07/2015	46	52	65	55	56
04/08/2015	55	62	74	68	65
15/08/2015	64	68	80	78	71
26/08/2015	67	71	82	80	72
06/09/2015	71	73	86	83	75

Table-10: Observation results (Seed Number of *Lens culinaris)* for Group-4. G stands for Group and P is for the Pot.

Mean Number of Seeds per Group					
Observation Date	Group-0-0 mg/10mL	Group-1-5mg/10mL	Group-2-10mg/10mL	Group-3-15mg/10mL	Group-4-20mg/10mL
15/05/2015	15.4	17.8	20.0	22.2	16.0
25/05/2015	17.6	21.8	23.8	26.0	18.4
04/06/2015	21.4	26.0	26.4	30.0	20.2
14/06/2015	30.4	34.2	36.8	41.2	26.2
24/06/2015	40.4	45.2	51.6	53.0	32.8
04/07/2015	51.2	54.6	61.4	69.2	39.0
14/07/2015	60.2	64.6	73.0	83.2	45.4
24/07/2015	71.6	80.8	85.4	93.0	54.8
04/08/2015	81.8	92.2	99.8	111.6	64.8
15/08/2015	91.8	104.6	110.6	124.0	72.2
26/08/2015	98.8	113.0	115.8	129.4	74.4
06/09/2015	102.8	116.2	119.8	135.0	77.6

Table-11: Mean Number of Seeds as per Groups. Averages from tables 6, 7, 8, 9, 10

ANOVA TEST

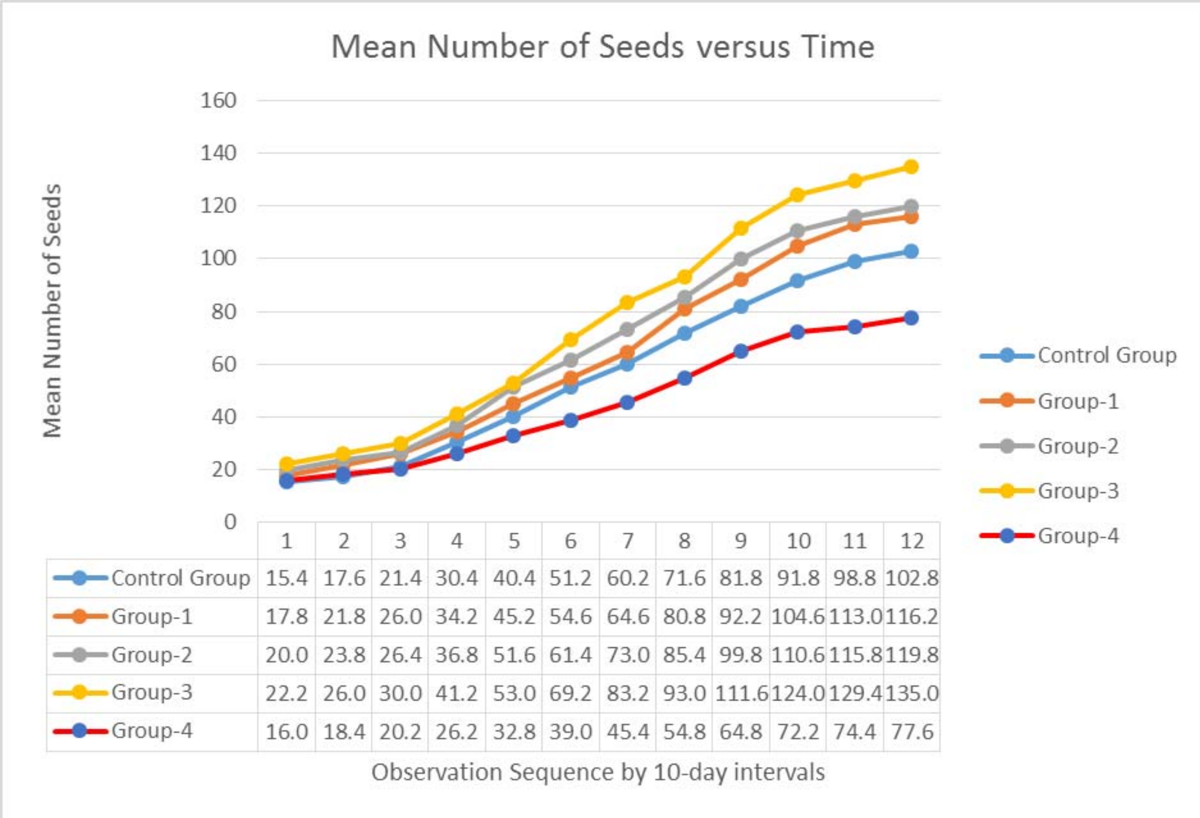
Analysis of Variance is conducted based on the number of seeds obtained in each pot for the respective amount of NH_3 solution at the end of experiment process.

	Pot-1	Pot-2	Pot-3	Pot-4	Pot-5
Control Group-No NH3 Solution	104	105	102	101	102
Experiment Group-1- 5mg/10mL of NH_3 solution	113	115	117	119	117
Experiment Group-2- 10mg/10mL of NH_3 solution	119	117	119	121	123
Experiment Group-3- 15mg/10mL of NH_3 solution	134	132	139	138	132
Experiment Group-4- 20mg/10mL of NH_3 solution	71	73	86	83	75

Table-12: Number of seeds obtained in each pot for the respective amount of NH_3 solution at the end of experiment process.

Anova: Single Factor						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Control Group-No NH3 Solution	5	514	102.8	2.7		
Experiment Group-1- 5mg/10mL of NH_3 solution	5	581	116.2	5.2		
Experiment Group-2- 10mg/10mL of NH_3 solution	5	599	119.8	5.2		
Experiment Group-3- 15mg/10mL of NH_3 solution	5	675	135	11		
Experiment Group-4- 20mg/10mL of NH_3 solution	5	388	77.6	42.8		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	9303.44	4	2325.86	173.8311	0.00000000000000313	2.866081402
Within Groups	267.6	20	13.38			
Total	9571.04	24				

Table-13: Anova test results



	1	2	3	4	5	6	7	8	9	10	11	12
Control Group	15.4	17.6	21.4	30.4	40.4	51.2	60.2	71.6	81.8	91.8	98.8	102.8
Group-1	17.8	21.8	26.0	34.2	45.2	54.6	64.6	80.8	92.2	104.6	113.0	116.2
Group-2	20.0	23.8	26.4	36.8	51.6	61.4	73.0	85.4	99.8	110.6	115.8	119.8
Group-3	22.2	26.0	30.0	41.2	53.0	69.2	83.2	93.0	111.6	124.0	129.4	135.0
Group-4	16.0	18.4	20.2	26.2	32.8	39.0	45.4	54.8	64.8	72.2	74.4	77.6

Graph-1: Graphical display of the production mean by groups in terms of number of seeds by 10-day observation intervals

CONCLUSION AND EVALUATION

When I was trying to find which research topic to choose, I decided to make a scientific research which would help developing and underdeveloped countries whose agricultural land and financial assets are limited find a relatively new approach for meeting their protein demand for especially women and children. When my experiment was finalizing, I discovered that United Nations launched 2016 International Year of Pulses, under the slogan 'nutritious seeds for a sustainable future,' celebrating benefits of legumes, which was very nice coincidence with my work. "Pulses are important food crops for the food security of large proportions of populations, particularly in Latin America, Africa and Asia, where pulses are part of traditional diets and often grown by small farmers," said FAO Director-General José Graziano da Silva, in a news release.

To explain observations to see if the hypothesis is accepted or rejected based on whether the means of the seeds grown in the experiment groups differentiate by chance or by the amount of fertilizer, Analysis of Variance (ANOVA) is conducted as an exploratory tool.

My null hypothesis is;

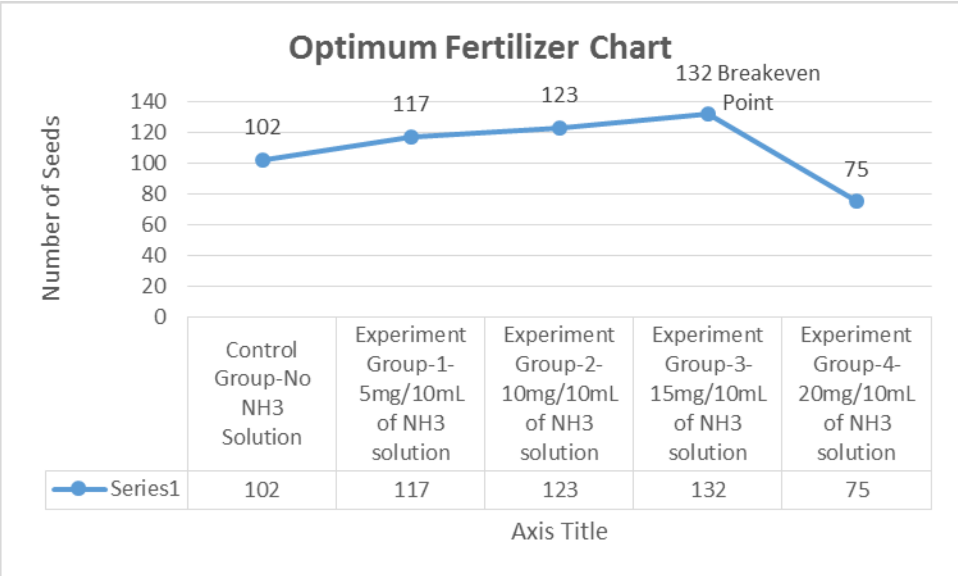
H_0*: *Number of Lens culinaris* (Lentil) seeds does not change by the amount of NH_3 *solution administered to.

According to date shown Table-13 the test result is significant because p-value (0.0000000000000028) is less than significance level which is 0.05 and 173.8311 (F) > 866081402 (F crit), that justify the rejection of the null hypothesis, ***H_0*: *Number of Lens culinaris* (Lentil) seeds does not change by the amount of NH_3 *solution administered to.*** And, ***H_1*: *Number of Lens culinaris* (Lentil) seeds change by the amount of NH_3 *solution administered to*** is accepted, which implies that variation among the mean values of the experiment groups occurred not by chance but by the amount of fertilizer.

At the beginning of the experiment my forecast was that *Lens culinaris* (Lentil) plant would produce more seeds gradually in direct proportion with the NH_3 *solution administered to until a certain amount (optimum point), and the production in terms of seed number would decrease in indirect proportion after that optimum amount. So, optimum point is a breakeven point where one obtains maximum number of seeds and exceeding amount of fertilizer will cause a decrease in the number.*

Timeline in Graph-1 is included to visually show the precision of my forecast that there is a breakeven point which implies an optimum amount of fertilizer. According to Graph-1, number of seeds are gradually increasing as per the amount of fertilizer rises, such as in

Control Group with no NH3 solution to 102 seeds, in Group-1 with 5mg/10mL of NH3 solution to 117 seeds, in Group-2 with 10mg/10mL of NH3 solution 117 seeds and in Group-3 with 15mg/10mL of NH3 solution to 135 seeds are obtained. After administering 15mg/10mL of NH3 solution in Group-3, number of seeds shows up a drastic fall to a mean 77.6 seeds with the administration of 20 mg/10mL of **NH_3** solution, which indicates an overdose of fertilizer usage has an adverse effect on the growth. As per my experiment's observations, **the optimal point has emerged at a level of 15mg/10mL of NH3 solution** for a group of six single *Lens culinaris* (Lentil) plant to obtain maximum number of seeds. This amount of fertilizer (15mg/10mL of NH3 solution) is a breakeven point (Graph-2) that implies an optimum amount of fertilizer to yield the maximum amount of seeds.



Graph-2: Breakeven point for the amount of fertilizer (NH_3 solution)

As it was stated in the research topic as **Optimum amount of ammonia (NH_3) solution concentration has the greatest effect on the growth of *Lens culinaris* (Lentil) counted by the number of seeds is being proved by the statistical results.**

In my research, I have endeavored to reveal the results for relationship between the amount of Nitrogen (**NH_3** solution**)** being an input, and number of seeds (which corresponds to productivity) per plant to shed a light for improved production of *Lens culinaris* (Lentil) in a hope to be a remedy for the hunger, starvation and deprivation of those in need, for a better and peaceful future for the humanity. My research clearly shows that optimum use of Nitrogen (**NH_3** solution**) in raising** Lens culinaris (Lentil), which is one the most accessible and affordable source of protein, could increase the productivity of farmers with less cost and provide more protein for those in the developing and underdeveloped countries.

When I visited Turkish Farmer Union to discover the actual usage of Nitrogen as fertilizer in the *Lens culinaris* (Lentil) cultivation, I was informed that Turkish farmers use 4 kg of Nitrogen fertilizer per decare of land. Turkish Farmer Union also stated that amount of seeds sown per decare is 9 kg. Average production efficiency is 150 kg/decare. To further validate what ANOVA test showed and meant, the real world data was obtained from Turkish Farmer's Union to put in comparison.

Production Efficiency Analysis and Comparison between the Results of Experiment and Actual Usage in the Field.

Essential Data for the Calculations:

1 Lentil seed=0.15 g

1 kg of Lentil= 6,666 seeds

Data and Production Efficiency from the Experiment:

Average number of Lentil seeds of 135 was obtained from 6 seeds in experiment Group-3 with 15 mg/10mL solution (administered 12 times though the experiment, amounts to 180 mg) which I found was optimal amount to receive maximum number of seeds.

Production efficiency is 135/6=22.5

If 9 kg (60,000 seeds) were sown in 1 decare of land, 1,350,000 seeds which amounts to 202.5 kg of Lentil would be harvested.

Data and Production Efficiency from Turkish Farmer's Union:

As per information given by Turkish Farmer Union, with 9kg of Lentil seeds, 150 kg. of Lentil is obtained.

9 kg X 6666= 59,994≅ 60,000 seeds

150 kg X 6666=999,900 ≅ 1,000,000 seeds

Production efficiency is 1,000,000 / 60,000 =16.66 ≅ 17

Fertilizer Comparison between the Results of Experiment and Actual Usage in the Field.

Data from the Experiment:

15 mg of ammonia (NH_3 solution) X 12 Administration throughout the experiment = 180 mg of Fertilizer for 6 seeds

For 60,000 seeds (9kg/decare) → 60,000X180mg= 10,800,000/6=1,800,000 mg→1,8kg of Fertilizer/Decare

Data from the Turkish Farmer's Union:

Turkish farmers use 4 kg of Nitrogen fertilizer per decare of land.

	Experiment	**Turkish Farmer's Union**	**Difference in mass**	**Difference in percentage**
Crop Sown (Interpolation) in 1 decare of land	60,000	60,000	N/A	
Crop harvested from 1 decare of land	**202.5 kg**	150 kg	**+ 43,5 kg**	**+ % 35**
Fertilizer used in 1 decare of land	**1,8 kg**	4 kg	**-2.2 kg**	**- % 45**
Production Efficiency	**22,5**	17	**+ 4.5**	**+ % 32**

Table-14: Comparison between Findings from Experience and Data from the Real World

As shown in Table-14, my experiment unequivocally show that it is possible to obtain more Lentils, hence an affordable and accessible source of protein, with less input such as fertilizers. It is clear that farmers who would use findings from this experiment could save 45% from fertilizer and obtain 35% more Lentils using the same amount of Lentil seeds and same size of land.

APPENDIX-1
CONTROL GROUP with no $\mathbf{NH_3}$ solution

GROUP-1 with 5 mg of $\mathbf{NH_3}$ solution

GROUP-2 with 10mg of $\mathbf{NH_3}$ solution

GROUP-3 with 15 mg of **NH_3** solution

GROUP-4 with 20 mg of $\mathbf{NH_3}$ solution

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